UNIVERSITI PUTRA MALAYSIA

EFFECTS OF ROOTING MEDIUM, LIGHT INTENSITY AND MISTING ON THE ROOT ABILITY OF SHOREA MACROPHYLLA LEAFY STEM CUTTINGS

TING SING TECK

EFFECTS OF ROOTING MEDIUM, LIGHT INTENSITY AND MISTING ON THE ROOTABILITY OF *Shorea macrophylla* LEAFY STEM CUTTINGS

BY

TING SING TECK

A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Tropical Forest Resource Management in the Faculty of Forestry, Universiti Putra Malaysia

May 2002

APPROVAL SHEET

Name of candidate : TING SING TECK

Title of Thesis : Effects of rooting medium, light intensity and misting on the rootability of *Shorea macrophylla* leafy stem cuttings

Approved by:

Dr. Mohamad Azani Alias
Supervisor

Assoc. Prof. Dr. Nor Aini Abd. Shukor
Examiner

Assoc. Prof Dr. Mohd Hamami Sahri
Acting Dean
Faculty of Forestry

Date: May 2002

DEDICATED TO MY BELOVED:

Father, Mother, Sister & Brother

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation and sincere thanks to my supervisor, Dr. Mohamad Azani Alias for his kind and untiring assistance, support and guidance throughout this study. I would also like to express my thanks to my first examiner Prof. Madya Dr. Nor Aini Abd. Shukor. Her valuable comments and criticisms were deeply appreciated and will always be remembered. My sincere thank is also extended to my second examiner, Dr. Mohd Zaki Hamzah for his advice.

I would also like to thank the Sarawak Indigenous Tree Centre (SITC) for permission to carry out study in Tatau, Bintulu. This work was made possible through the support of Goodmatch Sdn. Bhd. Special thanks to En. Abdul Rajak and En. Angga ak Entalai for assitance with field work, Mr. Ahmed Eldoma and En. Latib Senin for the data analysis.

Not forgetting also my friend, Miss Ding Mee Ting for her encouragement, my coursemates and all my friends who had helped me in one way or the other.

Last but not least, I an very grateful to my beloved parents, bothers and sisters, uncle and aunty for their encouragement and support through my studies in UPM.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE

LIST OF PLATES

LIST OF ABBREVIATIONS

ABBREVIATIONS

SITC	Sarawak Indigenous Tree Centre
AFTSC	ASEAN Forest Tree Seed Centre
PICOP	Paper Industries Corporation of the Philiphines
S	Sand
1CF1S	1:1 mixture of coconut fibre and sand
1CF2S	1:2 mixture of coconut fibre and sand
1CF3S	1:3 mixture of coconut fibre and sand
1SD1S	1:1 mixture of sawdust and sand
1SD2S	1:2 mixture of sawdust and sand
1SD3S	1:3 mixture of sawdust and sand
L1	1 plastic sheet
L2	1 plastic sheet (+) 1 layer of netting
L3	1 plastic sheet (+) 3 layer of netting

ABSTRACT

The effects of different proportion of rooting media, light intensity, and misting on the rooting of leafy stem cuttings of *Shorea macrophylla* were investigated in Sarawak Indigenous Tree Centre (SITC) The overall rooting percentage of *S. macrophylla* were 51 64% Significant differences ($P<0$ 05) were recorded between non-mist and mist, with non-mist system (55 03%) being better than mist system (48 25%) Cuttings inserted in 1 2 mixture of sawdust and sand by volume showed higher rooting percentage (57 11%) than those in different proportion of coconut fibre and sand Rooting percentage is the highest in L1 (control, plastic sheet, 71 63%) compared to L2 (1 layer of black netting + plastic sheet, 58 13%) and L3 (3 layers of black netting + plastic sheet, 25 17%) Higher mortality in L3 may be attributed to the lower photosynthetic rates, which was also associated with low light intensity received by the treatment The present results suggested that non-mist system which is enclosed with a transparent plastic sheet and used rooting medium of different proportion of sawdust and sand is a practical method to propagate vegetatively *S. macrophylla*

ABSTRAK

Kesan nisbah penggunaan media pengakaran yang berlainan, keamatan cahaya, dan pengaruh sistem renjisan terhadap pengakaran keratan berdaun *Shorea macrophylla* telah dikaji di Sarawak Indigenous Tree Centre Peratus pengakaran secara keseluruhan daripada kajian ini ialah 51 64% Terdapat perbezaan yang bererti di antara sistem berrenjisan dan tanpa renjisan, di mana peratus pengakaran yang lebih baik di dalam sistem tanpa renjisan (55 03%) berbandingkan dengan sistem berrenjisan (48 25%) Keratan yang ditanam di dalam campuran habuk kayu gergaji dan pasir dengan nisbah 1 2 menberikan peratus pengakaran yang lebih tinggi (57 11%) jika dibandingkan dengan campuran serat kelapa dan pasir dengan nisbah yang berlainan Peratus pengakaran adalah lebih tinggi di dalam L1 (kawalan, plastik yang lutsinar, 71 63%) dibandingkan dengan L2 (1 lapisan jaring hitam + 1 lapisan plastik, 58 13%) dan L3 (3 lapisan jaring hitam + 1 lapisan plastik, 25 17%) Kadar kematian yang tinggi di dalam L3 mungkin disebabkan oleh kadar fotosintesis yang rendah akibat dari kekurangan cahaya yang diterima oleh rawatan ini Keputusan kajian ini mencadangkan bahawa sistem tanpa renjisan yang dinaungi oleh 1 lapisan plastik yang lutsinar, dan yang menggunakan media pengakaran campuran nisbah habuk kayu gergaji dan pasir yang berlainan, merupakan cara yang praktikal untuk membaikbiak keratan *S. macrophylla*

CHAPTER 1

INTRODUCTION

1.1 General

Shorea macrophylla (De Vr) Ashton (Dipterocarpaceae) is a common Bornean timber-sized tree, valued for its oil-bearing fruits, and is one of the large-fruited species of 'illipe nuts' or commonly known as 'Engkabang jantong ' (Connell, 1968). The tree is mainly riparian, but does occur on flat or slightly undulating land that is well watered with small streams.

This Borneon species with exceptionally fast growth, can achieve mean annual increment (MAI) of 8.83 m^3/ha (Appanah and Weinland, 1993). It has wide spreading crown with big limbs. Regeneration is dense, which react instantly to gaps and the poles reach canopy within a few years. It is phototropic, and needs to be carefully trained as a young plant. It needs medium shade for training, and in gap conditions it grows with excellent form. It makes an excellent species for line planting into secondary growth. On cleared sites, it needs a nurse crop. In Kepong, Engkabang jantong achieved 48 cm diameter in 23 years. In the Semengoh plantations, Sarawak, the species attained an annual diameter increment of 1.22 cm (Tan et al., 1987). This represents about 2 to 3 times higher than in both primary and logged forests (Appanah and Weinland, 1993).

Vegetative propagation of dipterocarps, e.g. *S. macrophylla*, has been the interest to agriculturist in Sarawak because of their oil-bearing fruits. This is why it is included as one of the species included in domestication programs of tropical tree species (Lo, 1985)

Dipterocarps exhibit erratic fruit setting, taking 2 to 10 years between seeding years (Ashton et al., 1988), and the seeds are recalcitrant preventing long-term storage (Sasaki, 1976, 1980; Boontawee and Nutivijarn 1989, Tompsett, 1989). Vegetative propagation by cutting has been investigated as an alternative method of supplying planting material of dipterocarps (Momose, 1978, Halle and Kamil, 1981, Srivastava and Manggil, 1981, Smits, 1983, 1986, Smits et al , 1987, 1990, Aminah, 1991a,b,c, Noraini and Ling, 1993, Moura and Lundoh, 1994, Aminah et al , 1997a,b, 1999, 2000) However, dipterocarps are considered difficult to root (Anon, 1973-1976, Manurung, 1977, Philips, 1980)

1.2 Justification and objective

Cutting which is one of the most common methods of vegetative propagation used in forestry, is simple, easier, and could lead to the large scale and uniform multiplication of desirable plus tree genotypes with subsequently less phenotypic variation in the resulting plants It can be produced as scheduled for forest rehabilitation and plantation project

Thus to successfully apply vegetative propagation by cuttings it would definitely require an extensive scientific research into the optimum conditions and techniques to be used as this techniques is influenced by a multitude of internal and external factors Such findings can also provide a basis for formulating suitable and operational planting methods and systems for propagating the valuable indigenous forest species

Thus, this study examines the possibility of raising planting stock using cuttings of *S. macrophylla*, by using different proportion of rooting media, light intensity, and also misting system The objectives also include

a) To determine the type of media, levels of light intensity and misting system for raising planting stock of *S. macrophylla*
b) To establish optimum relationship between or among factors for the purpose of rooting of cutting

CHAPTER 2

LITERATURE REVIEW

2.1 Vegetative propagation by cutting

Rooting of cutting is one of the methods of vegetative propagation in which a portion of a stem, leaf, or root is cut from the parent plant, and then placed under certain favourable environmental conditions to induce formation of shoots and roots thus producing a new independent plant, which in most cases, is identical with the parent plant (Hartmann and Kester, 1983). The success in rooting of a plant part depends upon the ability of cells within it to change their function, divide and produce new cells, which will in turn form new organs (Hammett, 1973).

Cuttings are the most widely used method of vegetative propagation in various fields such as horticulture, agriculture and no less in forestry. It involves a wide range of plants, namely, ornamental shrubs of both deciduous and broad- and narrow- leaved evergreens, agriculture crops, and many temperate and tropical forest tree species.

The wide application of cuttings is attributed to their numerous advantages. Cuttings are basically inexpensive, fast, and simple, and also does not require any special techniques such as in grafting or budding. It can also alleviate the problem of graft incompatibility (Hartmann and Kester, 1983; Zobel and Talbert, 1985) besides creating greater uniformity in planting stock. Cuttings also enable the preservation and multiplication of desired parental genotypes or traits which could capture the maximum genetic gains when used for regeneration planting programmes. Besides that, they also speed up the reproductive cycle for accelerated breeding and propagation because cuttings can be used to overcome long juvenile periods in many plants (Leakey, 1987; Zobel and Talbert, 1985). Of the various types of cuttings, stem cutting is the most popular.

A large number of propagules have been successfully produced from a single tree by means of stem cuttings of *Eucalyptus* spp. including *E. grandis*, *E. camaldulensis*, *E. polybractea* and *E. occidentalis* (Hartney, 1980). McComb and Wroth (1986) also showed that rooted cuttings could be produced from coppices of two species of *Eucalyptus*, About half a million cuttings were harvested and planted from 3000 selected and coppiced clones of *Gmelina arborea* (Yemane) in an improvement programme of the species in Sabah in 1981 (Sim and Jones, 1985; Leakey, 1987).

Preliminary evaluation of plantations established using rooted cuttings have been reported in *Picea mariana* Mill. B.S.P. (black spruce) and *Pseudotsuga menziesii* Mirb. (Douglas fir) by Armson et al (1980) and Ritchie and Long (1986) respectively. Rooted cuttings of *Picea mariana* was generally more successful and maintained over 90 per cent field survival after three months being outplanted. However, it is commonly feared that rooted cuttings may in some way have root systems that are inferior to those of seedlings, and consequently, clonal plantings are more susceptible to wind besides having pest and disease problems due to its massive, biologically uniform stands (Leakey 1987).

Numerous research results were reported from cutting trials of *Pinus radiates* (Smith and Thorpe, 1975a;b; Burden and Bannister, 1985), and the African tropical and subtropical hardwood species of *Triplochiton scleroxylon* K. Schum (obeche, wawa or samba) (Leakey et al., 1982; Leakey and Mohammed, 1985) and *Populus* species (Nanda and Kochhar, 1968; Nanda and Anand, 1970; Nanda et al., 1973; Okoro and Grace, 1976; Deol and Khosla, 1983).

Cutting trials on potential tropical dipterocarp species such as *Shorea leprosula* (Meranti tembaga) (Eric, 1979; Halle and Hanif 1981; Alias, 1984; Ng, 1988; Liew, 1992; Aminah et al., 1997a; Aminah et al., 1997b; Aminah et al., 2000), *S. curtisii* (Meranti seraya) (Annuar, 1989; Liew, 1992), *S. ovalis* (meranti kepong) (Eric, 1979; Hamsawi,1981; Alias, 1984), *S. acuminata* (Noraini and Ling, 1993), *S. parvifolia* (Noraini and Ling, 1993), *S. bracteolata* (Aminah, 1991a), *Hopea odorata* (Aminah, 1991c), *Dryobalanops lanceolata* (Moura and Lundoh, 1994), and *S. macrophylla* (emgkabang jantong) (Lo, 1985) have showed various degree of rooting success depending on various factors involved for rootability.

Eric (1979) reported that there was a considerable variation in rooting capacity between the different species even though belonging to the same family, such as in Dipterocarpaceae. Juvenility is a very important factor favouring vegetative propagation of tropical timber species (Momose, 1978; Ng, 1988).

Vegetative propagation techniques have been developed for *S. macrophylla* to overcome difficulties of seed supply, and to encourage reforestation efforts in Sarawak. Different results have been obtained where some are encouraging whereas some are not satisfied. Further studies are needed to verify the rootability of this species, and to determine the optimum conditions to obtain the highest possible rooting success.

2.2 Misting system

To control the environmental conditions in a propagation system effectively, an understanding of the processes the microclimate of the cutting beds is essential (Loach, 1988). Successful propagation is dependent on the maintenance of suitable and leaf temperature, irradiance and leaf-to-air vapour pressure deficit (VPD) for the metabolic processes involved in rooting (Grange and Loach, 1983a; Loach, 1988b). As rooting is dependent upon maintenance of turgor in the cutting (Loach, 1977), and as water loss from cuttings is primarily influenced by VPD, the quantification of VPD in different propagation environments is particularly useful (Grange and Loach, 1983a;b).

The environmental characteristics of the many different propagation systems used in commercial horticulture have been reviewed in detail by Loach (1988b). This survey highlighted how few detailed comparisons of microclimate have been made in different propagation systems. Hess and Synder (1955) found that leaf temperatures were lower under mist than under glass frames, which resulted lower VPD in the mist system, and consequently more successful rooting. In a comparisons of three different systems (mist, polyethylene tent and contact polyethylene), Grange and Loach (1983a) found that the relationship between incident irradiance and VPD was linear in each case, although the systems differed significantly in the VPD at a given irradiance.

In many tropical countries, the high capital and running costs of mist systems make them inappropriate, except for large commercial projects. Non-mist propagators, which can be operated in the absence of mains electricity, are enabling vegetative propagation to be carried out in rural areas (Leakey et al., 1990). As noted by Loach (1988b), non-mist system requires more intensive management, which should be based on an appreciation of the environmental principles involved. Apart minimizing opening of the propagator lid, and the maintenance of wet internal surfaces inside the propagator, this will primarily involves use of shading (Grange and Loach, 1983a,b; Leakey et al., 1990).

In mist-spray propagation, leaves remain cool through evaporation of the film of water on them. The V (leaf) and LAVPC remain low and water loss was restricted, maintaining turgidity in the cuttings. The effects of mist and non-mist on leaf and air temperature are detailed in Table 1.

Table 1. The effects of mist and non-mist on selected parameters (Loach, 1983)

Parameter	Mist	Without
Leaf temperature (°C)	21.7	28.9
Air temperature (°C)	22.0	26.8
Leaf vapor pressure (kPa)	2.6	4.0
Air vapor pressure (kPa)	2.6	2.2
Leaf-to-air vapor pressure gradient (kPa)	0.6	1.8

It should be pointed out, however, that the spray seldom reaches the leaf undersurfaces, where the majority of stomata are located. Loss of some tissue water from exposed portions of the foliage is therefore unavoidable.

Increasing misting frequency can increase nutrient leaching from the leaves as well as in the rooting medium, and reducing oxygen diffusion to developing root initials. More frequent misting also reduces evaporative cooling of leaves and increases V (leaf), so that the expected reduction in LAVPG is not being fully realized. Another reported advantage of mist spraying, compared to propagation under enclosures, is that higher levels of light intensity could be tolerated, thus causing increasing photosynthesis in cuttings (Macdonald, 1990).

A mist-spray reduces fluctuations in ambient humidity. Richards (1984) compared the open bench mist-spray system with the enclosed mist-spray system. Depending on species, rootability was 14% higher, on average, in the enclosed mist-spray system. It should also be noted that electricity requirements for an open bench mist-spray system is higher because of more frequent misting.

The Sepilok Forest Research Centre, Sabah, Malaysia has identified the following potential problems presented by mist-spray propagation systems (Thomas, 1987):

- Unreliable power supplies.
- Faulty or poorly functioning mist-spray control units.
- Inadequate water pressure or supplies because of small and unsuitable water pumps or other factors.
- Water with a high sediment content.

A mist-spray propagation system must have reliable equipment, which should be carefully monitored and calibrated to ensure optimal conditions, and operated by trained personnel.

2.3 Rooting medium

Rooting medium is one of the major environmental factors influencing the rooting of cuttings According to Eric (1979), Hartmann and Kester (1983), the rooting medium has three functions

- To hold the cutting in place during the rooting period
- To provide moisture for cutting
- To permit aeration to the base of the cutting

Cuttings root well with cool, moist air at the top and a warm, solid, medium around the base This temperature gradient allows for greater activity at the base while minimizing respiration and moisture stress at the top The benefits of a higher temperature in the rooting medium are greatly reduced at 22 °C or higher (Rauter 1982)

Rooting media are an integral part of the propagation system The propagation of organic and mineral components in the medium should vary according to the wetness of the propagation system A well-aerated medium was probably necessary with frequent misting In PE-covered enclosures, a medium with good water-holding capacity may be desirable

Various rooting media have been tried, including sand, soil, water, peat moss, vermiculite, perlite and sawdust, either singly or in combinations However the optimum for each species will depend on the type of cutting under which they are propagated (Eric 1979, Lie, 1992) The ideal rooting medium for producing cuttings should have the following characteristics including fibrous, porous, light weight, easily available and low cost

The type of rooting medium used is also important to the rooting process Cuttings of many species root successfully in a variety of rooting media (Leakey et al , 1990), but the rooting performance, in term of both number of roots and rooting percentage, may be greatly influenced by the kind of rooting medium used (Leakey et al., 1990, Ofori et al., 1996; Shiembo et al., 1996a; Mesen et al., 1997)).

It was also indicated that coconut fibre and paddy husk produced better root growth and development in cuttings of *Shorea* species compared to those rooted in the conventional sieved river sand, possibly because of the nutrient availability in such rooting media compared to sand (Liew, 1992). Research conducted at ACFTSC (Kijkar, 1991a; Pong-anant and Kijkar, 1991) on different rooting media for producing rooted cuttings of *E. camaldulensis* indicates that coconut husk is clearly superior to other potting media such as sand, soil, and mixtures of soil, sand, coconut husk, and rice-husk coke.

Some successful experiments on the rooting of indigenous hardwood species cuttings have been achieved using sand as growth medium (Eric, 1979; Noraini and Ling, 1993; Moura and Lundoh, 1994; Aminah et al., 1997a;b; 1999; 2000).

2.4 Light intensity

During propagation, the primary effects of irradiance are on assimilate production and water use of the cuttings (Eliasson and Brunes, 1980; Klass et al., 1985; Hartmann et al., 1990). High irradiance increase leaf temperature causing an increase in leaf-to-air vapor pressure difference, and thus an increase in transpiration rate (Grange and Loach, 1983a; 1983b; Loach, 1988a; 1988b). Rapid transpiration is often lethal to cuttings that have not rooted. Moreover, the warming of air is likely to increase the saturation deficit over the leaf, exacerbating the process of desiccation (Evans, 1952; Kemp, 1952; Hess and Snyder, 1955; Loach, 1988a; 1988b; Hartmann et al., 1990). To reduce the effect of high irradiance on cuttings, propagators are shaded (Loach, 1977; Loach and Whalley, 1978; Loach and Gay, 1979); however, there have been few attempts to quantify the effect of irradiance on dipterocarp cuttings during rooting (Moura and Lundoh 1994; Smits et al., 1994, Aminah et al., 1997a).

Light was required for the production of carbohydrates during photosynthesis. The effects of light on rooting processes can be due to the quality and intensity of the light. The light compensation point (the minimum light intensity required for photosynthesis) of young dipterocarp seedlings (*Shorea*, *Hopea*, *Dipterocarpus*, and *Vatica*) was 400-1600 Lux (1.6-6.4% of full sunlight on an overcast day). The light saturation point (the point at which a further increase in light intensity does not result in more photosynthesis) was at 30-50% of full sunlight, depending on species (Sasaki and Mori 1981). Seedlings with hardened tissues and well-developed root systems (low shoot: root) can be produced at higher light intensities. There was no value in providing excess light to stocks when the objective was cutting production.

2.5 Rooting hormone

The ability of auxins to promote adventitious root development in stem cuttings is well known, and has been attributed to enhanced transport of carbohydrate to the base of the cutting (Hartmann et al., 1990; Leakey, 1990). However, relatively high concentrations of auxins have been reported to be inhibitory to rooting, indicating that in many species, optimal concentrations may be defined (Leakey et al., 1982).

Lo (1985) showed that 1200 ppm and 3600 ppm IBA, did not enhance the rate of rooting after 61 days. However, he found that 3600 ppm IBA was more effective than 3600 ppm NAA and mixtures of 1800 ppm NAA + 1800 ppm IBA. He also reported that higher concentration of IBA could cause mortality, for instance high mortality was recorded when using 10800 ppm IBA.

2.6 Water relation

The maintenance of adequate water supply to the tissues of a cutting while it is forming new roots presents the greatest problem to this form of plant propagation

(Hammet, 1973). According to Loach (1977), leafy cuttings need to retain their turgidity until new roots have developed.

As such, propagation procedure must ensure that high leaf water potentials are maintained in order to obtain optimal rooting, but conventional methods do not always achieve this (Loach, 1977). Separation of leafy cuttings from the stock plants cuts off the natural supply of water and nutrients, but yet the leaves are still capable of losing water by transpiration.

Water stresses and low leaf water potential within the cutting reduce the metabolic activity and cell regeneration, and consequently retarding the root initiation and development (Eric, 1979). Reducing the number of leaves of a cutting or trimming of leaves are normally carried out to reduce transpiration rate (Hammet,1973; Eric, 1979; Alias, 1984; Aminah, 1991c; Liew, 1992; Shiembo et al., 1996a, Aminah et al., 1997b).

In addition to that, Loach (1977), Hartmann and Kester (1983) noted that transpiration of the leaves on cuttings can be minimized by reducing the leaf-air water vapour pressure gradient. This can be achieved by the use of mist propagation in which water loss from the leaves is reduced by water mist sprays directly on the leaves, and hence reduces leaf temperature, air temperature, and the leaf-air vapour pressure gradient while maintaining a high humidity environment around the leaves. To control the environmental conditions in a propagation system effectively, an understanding of the processes influencing the microclimate of the propagator is essential (Loach, 1988b). Successful propagation is dependent on the maintenance of suitable air and leaf temperature, irradiance and leaf –to-air vapour pressure difference (VPD) for the metabolic processes involved in rooting (Grange and Loach, 1983a; Loach, 1988b). As rooting is dependent upon maintenance of turgor in the cutting (Loach, 1977), and as water loss from cutting is primarily influenced by VPD, the quantification of VPD in different propagation environments is particularly useful (Grange and Loach, 1983 a; b). The environmental characteristics of the many different propagation systems used in commercial horticulture have reviewed in detail by Loach (1988b). Hess and Snyder (1955) found that leaf temperatures were lower under mist than under double glass frames, which resulted in much lower VPD in the mist system, and consequently more successful rooting. In a comparison of the three different systems (Mist, polyethylene tent and contact polyethylene), Grange and Loach (1983a) found that the relationship between incident irradiance and VPD was linear in each case, although the systems differed significantly in the VPD at a given irradiance.

Propagation under polythene sheets also ensures that the atmosphere surrounding the cuttings is almost permanently saturated, so that water loss is then determined mainly by leaf temperature through its influence on the leaf vapour pressure (Loach 1977). The use of shading in propagation frames also reduces leaf temperature and decreases the vapour pressure within the leaf of cuttings.

Mist propagation system are commonly used for rooting cuttings of tree species in Malaysia including dipterocarps, either with or without enclosures (Momose, 1978; Muckadell and Malim, 1978; Halle and Kamil, 1981; Srivastava and Manggil, 1981; Lo, 1985; Aminah, 1991a;c; Noranini and Ling, 1993; Moura and Lundoh, 1994). It has been noted in many studies that newly planted cuttings were sensitive to water deficit prior to rooting which in turn affects the physiological processes of cuttings and hence their rooting ability (Loach, 1977; Loach, 1988a; b; Newton & Jones, 1993). The limits of tolerance o water deficits in cuttings have not been well defined (Newton and Jones, 1993).

Intermittent mist water sprays is currently the universally used misting system, in which water is applied at frequent short intervals controlled by automatic timer (Hartmann and Kester, 1983). Continuous misting is unfavourable due to lowering of temperature of rooting medium, too low for optimum besides causing waterlogged conditions and impairment of aeration. However, Lo (1985) obtained a higher rooting success for *S. macrophylla* cuttings with continuous misting compared to alternate misting.